

Claims

- [c1] A method for forming a buried plate in a trench capacitor, the method comprising the steps of:
forming at least one trench with a sidewall in a semiconductor substrate;
partially filling the trench with a dopant source material to form a dopant source having a top surface below a top of the trench, the dopant source material containing at least one dopant;
forming a dielectric collar on the sidewall of the trench above the dopant source;
heating the substrate to cause the dopant to diffuse into the substrate in the trench not covered by the dielectric collar, thereby forming the buried plate; and
removing the dopant source material from the trench.
- [c2] The method of Claim 1, wherein the semiconductor substrate is formed of silicon.
- [c3] The method of Claim 1, wherein the trench is partially filled by a method comprising the steps of:
filling the trench with a dopant source material to form a dopant source having a top surface at or above the top of the trench; and
recessing the top surface of the dopant source below the top

of the trench.

- [c4] The method of Claim 1, wherein the dopant source material is arsenic-doped glass.
- [c5] The method of Claim 1, wherein the dielectric collar is formed of nitride.
- [c6] The method of Claim 5, wherein the dielectric collar is formed by low pressure chemical vapor deposition.
- [c7] The method of Claim 5, further comprising the step of forming a thin layer of oxide on the sidewall of the trench prior to forming the dielectric collar.
- [c8] The method of Claim 1, wherein the substrate is heated to a temperature of about 800 C to about 1200 C, for a time of about 1 to about 60 minutes.
- [c9] The method of Claim 8, wherein the substrate is heated to a temperature of about 1050 C.
- [c10] The method of Claim 1, wherein the substrate is heated in an oxygen-containing atmosphere.
- [c11] The method of Claim 10, wherein during the heating step, a layer of oxide is grown between the dopant source material and the substrate.
- [c12] The method of Claim 11, further comprising the step of

removing the layer of oxide, thereby forming a bottle-shaped trench.

- [c13] The method of Claim 1, further comprising the step of depositing a plurality of hemispherical grains in the trench after the dopant source material is removed.
- [c14] The method of Claim 1, further comprising the step of removing the dielectric collar.
- [c15] The method of Claim 1, further comprising the step of etching the substrate in the lower portion to form a bottle shape trench after the dopant source material is removed.
- [c16] The method of Claim 15, wherein the substrate is etched using ammonia.
- [c17] A method for forming a buried plate in a trench capacitor, the method comprising the steps of:
 - forming at least one trench with a sidewall in a semiconductor substrate;
 - partially filling the trench with a dopant source material to form a dopant source having a top surface below a top of the trench, the dopant source material containing at least one dopant;
 - depositing a second material on the dopant source, thereby filling the remainder of the trench and covering the sidewall of the trench above the dopant source;

heating the substrate to cause the dopant to diffuse into the substrate in the trench not covered by the second material, thereby forming the buried plate; and
removing the second material and the dopant source material from the trench.

- [c18] The method of Claim 17, wherein the semiconductor substrate is formed of silicon.
- [c19] The method of Claim 17, wherein the trench is partially filled by a method comprising the steps of:
 - filling the trench with a dopant source material to form a dopant source having a top surface at or above the top of the trench; and
 - recessing the top surface of the dopant source below the top of the trench.
- [c20] The method of Claim 17, wherein the dopant source material is arsenic-doped glass.
- [c21] The method of Claim 17, wherein the second material is undoped oxide.
- [c22] The method of Claim 21, wherein the second material is deposited by low pressure chemical vapor deposition or high density plasma chemical vapor deposition.
- [c23] The method of Claim 17, wherein the substrate is heated to a

temperature of about 800 C to about 1200 C, for a time of about 1 to about 60 minutes.

- [c24] The method of Claim 23, wherein the substrate is heated to a temperature of about 1050 C.
- [c25] The method of Claim 17, wherein the substrate is heated in an oxygen-containing atmosphere.
- [c26] The method of Claim 23, wherein during the heating step, a layer of oxide is formed between the dopant source material and the substrate.
- [c27] The method of Claim 1, further comprising the step of exposing the substrate to at least one of gas phase doping, plasma doping and plasma immersion ion implantation.
- [c28] The method of Claim 13, further comprising the step of exposing the substrate to at least one of gas phase doping, plasma doping and plasma immersion ion implantation, after depositing a plurality of hemispherical grains.